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SYMBOLIC ANALYSIS OF A MECHATRONIC DRIVE USING THE PROGRAM SAMD

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Abstract: *The paper presents practical application of the new developed program SAMD on a mechatronic drive unit, consisting of a PWM dc-to-dc converter and a permanent-magnet dc motor, to get results of both its symbolic and semisymbolic analyses. Above all it is shown how to create individual purpose-oriented models of that drive to obtain transfer functions, poles and zeroes, frequency characteristics and step responses for both the input supply voltage and the controlling duty ratio.*

Keywords: ***mechatronic drive, PWM dc-to-dc converter, permanent-magnet dc motor, symbolic analysis, program SAMD.***

Computer-aided symbolic analysis of drives as complex mechatronic systems

Mechatronic drives, both with AC and DC motors, come through a fast evolution due to the fact that they absorb progressive trends in electrical engineering, particularly in power electronics and digital control systems.

Till lately, DC motors of controlled or regulated drives were commonly driven from AC power network via controlled SCRs (Silicon Controlled Rectifiers). If only a source of DC voltage (e.g. batteries, diode rectifier, etc.) was available for a concrete application, DC motor could be controlled or regulated only via the lossy resistor regulation (rheostat, resistor voltage divider, power amplifier). Such methods are energetically inefficient. Currently, this drawback can be overcome by means of DC-DC switched converters with pulse width modulation since their efficiency can even exceed 95 %.

The initial stage of designing arbitrary controlled or regulated mechatronic drive is characterized by a necessity of acquiring a lot of information about static and dynamic parameters of drive motor and its power supply unit, which represent – in their mutual interaction – the actuator of the drive. The following quantitative indicators are particularly important: the system stability, poles and zeros and their location in the Gauss complex plane, the gain, the amplitude and phase frequency responses for controlled variable, etc.

In order to obtain the above characteristics of the mechatronic drives, consisting of sub-blocks of different physical nature, special software called SAMD (**S**ymbolic **A**nalysis of **M**echatronic **D**rives) has been developed. It is shown in the paper how to use this program for acquiring the data for the analysis of dynamical properties of the actuator of DC mechatronic drive that contains the boost DC-DC converter and the permanent magnet DC motor.

The SAMD program provides the results in the symbolic form which can be advantageous in comparison to the programs which are based on the numerical algorithms. Since the PWM switch forms the core of the analyzed switched DC-DC converter, the well-known concept of its averaging model has been used. It is widely used for effective computer analysis of small-signal AC analysis, as well as the transient and DC analyses. Its main benefit is the easy implementation of the switch model into the SPICE-family circuit simulators. However, these programs, based on conventional numerical algorithms, do not generate – with a few exceptions – some outputs, which are frequently required, especially for AC analyses of line-to-output and control-to-output behavior: zeros and poles of transfer functions and these transfer functions in the symbolic form, i.e. in the form of formulas. To obtain

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them, one has to perform complicated analytical calculations. The availability of such “hand-and-paper” procedures is strongly limited by the complexity of the system model.

The above analyses are provided algorithmically via SAMD. The following mechatronic systems have been modeled and analyzed in the paper: DC motor with permanent magnets, switched DC-DC boost converter, and DC mechatronic drive with switched DC-DC boost converter. The latter model was implemented via integration of two sub-models, first serving for modeling the transfer of the input voltage to the motor speed, and the second for modeling the duty ratio to the same speed (see Fig. 1 for the illustration). The following results are available: transfer functions in the symbolic and also semi-symbolic forms, zero/pole location, step and pulse responses in the semisymbolic form (i.e. as analytical functions of time), and, of course, the corresponding graphs (frequency characteristics and time-domain waveforms).

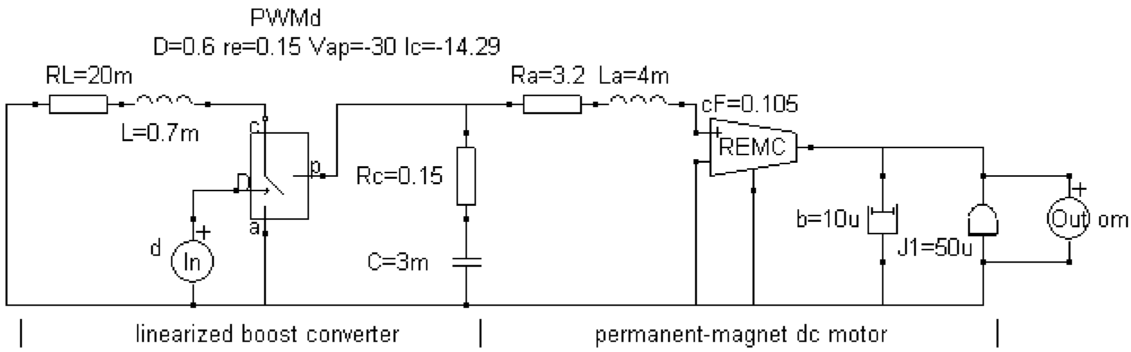

Fig. 1: Linearized model of the drive.

Conclusion

It is demonstrated on several examples in the paper that the computer-aided symbolic analysis can be useful for studying the properties and characteristics of linearized mechatronic systems that contain both the electric and mechanical subsections.

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